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Investigating Spring Back Characteristic of Construction Domain Aluminium Alloy Sheets upon Subjected to Stamping

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Abstract

Nowadays, aluminum alloy is widely used in spatial structures, and aluminum alloy gusset joint is also the most widely used connection method in spatial structure. With the improvement of the requirements of architectural design effect, aluminum alloy structure is becoming one of the forms of special-shaped space. Combined with the shape structure of curved reticulated shell, its gusset plate is usually made of arc plate formed by stamping. However, due to its low elastic modulus, poor plastic deformation ability at room temperature and uneven distribution of stress and strain, the metal sheet begins to spring back after the stamping load is unloaded. At present, the main spring back control methods for aluminum alloy plate are laser peen forming, cold stamping forming and multi- point forming. There are three kinds of spring back prediction methods for sheet metal forming: analytical method, finite element method and experimental method. Spring back is one of the most prominent and complicated problems during the processing and formation of the aluminum alloy sheet. The final shape of the curved panel is also dependent on the spring back after formation. When the spring back exceeds the allowable error, it will directly affect the appearance of the component, and therefore, the overall assembly. Ultimately, the bearing performance will further affect the safety protocols involved in respective components.

Keywords: Aluminum alloy sheet; Spatial structures; Curved reticulated shell; Stamping forming; Spring back

Introduction

Application of aluminum alloy in building structures

Owning to its light weight, high strength, strong plasticity, low maintenance cost, and good corrosion resistance, aluminum alloy materials have become a new type of construction material that promotes sustainable development in various domains. As a structural material, aluminum alloy has been widely used in aviation, machinery, shipbuilding, aerospace, automobile manufacturing and other fields [1]

The application of aluminum alloy in building structure can be traced back to the 1930's, and it is also mainly used in bridge structure. Currently, it is more widely used in transportation, construction, machinery and manufacturing. In the developmental process of the construction field, aluminum alloy has gradually demonstrated its advantages in combination with large-span spatial structures. The development of aluminum alloy spatial structures is later than that of steel grid structure and steel reticulated shell structure. The first aluminum alloy reticulated shell structure in the world was built in the United Kingdom, which is known as the dome of discovery [2] as shown in (Figure 1).

Figure 1: Dome of Discovery in England.

Since the 1950's, some European and American countries have used aluminum alloy as the load-bearing structure of buildings. After Mr. Fuller first proposed the concept of geodesic spherical dome in 1964, the application of aluminum alloy geodesic spherical dome in the United States has become more and more extensive, such as the Spruce Goose in Los Angeles built in the 1970's, as shown in (Figure 2).

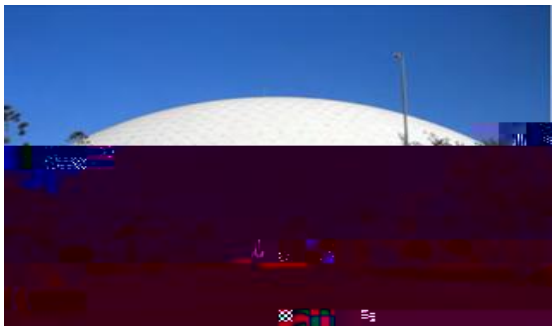

Figure 2: Spruce Goose.

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Figure 3: Caspary Auditorium.

In 1992, the Back River Wastewater Treatment Plant was built in Maryland of the United States, which is used for building anti-corrosion requirements, as shown in (Figure 4).

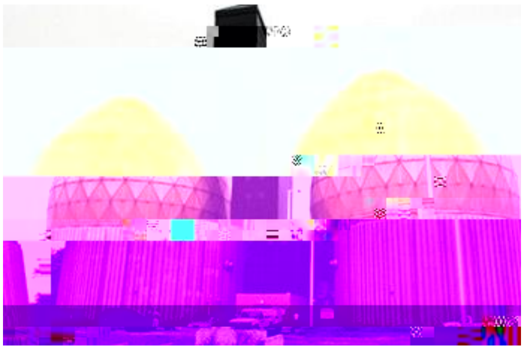

Figure 4: Back River Wastewater Treatment Plant.

Up to now, there are about 7000 aluminum alloy single-layer latticed shells in use in the United States. Aluminum alloy space grid structure can maintain good performance in humid environment, so it is increasingly widely used in the world. One of the most representatives is the first greenhouse of Niigata prefectural botanical garden built in Japan, which applied the single-layer spherical reticulated shell in 1998 as shown in (Figure 5).

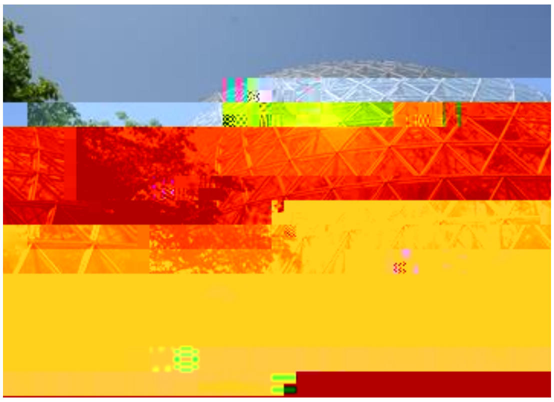

Figure 5: Niigata Prefectural Botanical Garden.

Spatial structure is mainly divided into grid structure and reticulated shell structure. It is a spatial structure composed of roughly the same grid or smaller units, which can uniformly transfer forces in three directions. Japanese scholars Hiyama and Ishikawa [3-5] have done static finite element simulation of aluminum alloy double-layer grid, and proposed that the criterion of dynamic collapse failure of grid can be determined by the critical displacement of the joint between the roof and the substructure. In 1996, Sugizaki [6] and others adopted the scale test method to analyze four aluminum alloy single-layer spherical latticed shells with diameter of 4.2m. The test results show that the bearing capacity of the latticed shell with only concentrated load at the top is higher than that with only uniform load.

Stamping Method of Aluminum Alloy Plate

Laser peen forming

Laser forming uses laser to provide energy, forming objects and

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4. Hiyama Y, Ishikawa K, Kato S, Okubo S (2000) Experiments and

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